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The Detonating Meteor of October 2nd, 1926

By F. J. W. WHIPPLE, M.A., F.INST.P.

I have taken an interest in detonating meteors since the beginning of 1923, when it occurred to me that one way of learning about the temperature of the air at great heights would be to study the records of such meteors. The idea was that the time that elapsed between the explosion of a meteor and the arrival of the sound would depend on the temperature of the air traversed by the sound-wave. I was able, however, to find no observations that looked sufficiently precise. Detonating meteors are not infrequent, however, there are some nearly every year in this country, so it was clear that if attention was given to the matter suitable observations should be forthcoming.

The brilliant meteor of September 6th, 1926, which produced considerable excitement in south Yorkshire gave an opportunity, and several newspapers published my request for information. Unfortunately the greater part of the course of this meteor was over cloud. Moreover it did not happen that any observers made on the spot close estimates of the time that elapsed before they heard the sound after they saw the illumination in the sky. The discussion of the observations has not led at present to results which serve for my special object.

The attention which had been drawn to the subject served a good purpose however. On October 2nd Mr. H. E. Brooking, of Kew Observatory, saw a fine meteor from Richmond Park and

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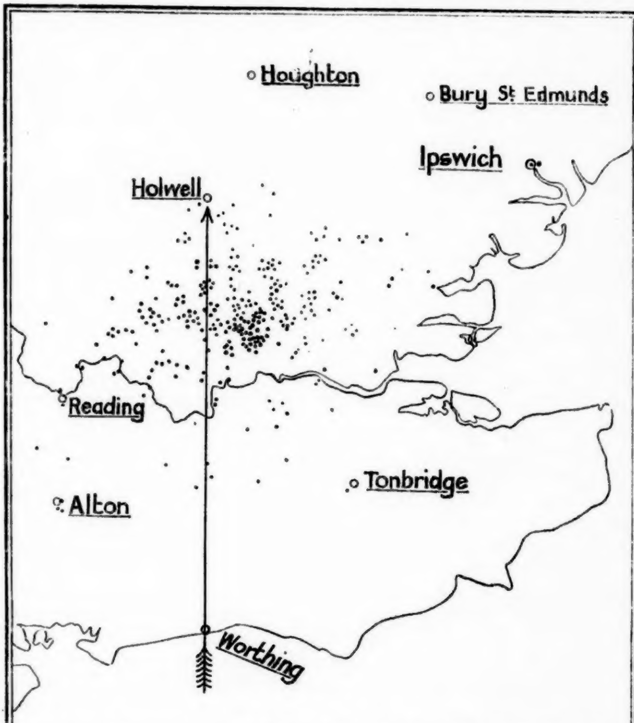
heard the detonation. I received his report at the same time as one from Mr. A. C. Armitage, of Letchworth. On the strength of these two reports an appeal for observations was issued through the Air Ministry. About 700 replies to this appeal have been received at Kew Observatory. The correspondence shows that the meteor, which appeared at 8.27 p.m., B.S.T., was seen over a very large area, stretching from Boulogne to Pontypool, from Corfe to Barnsley. The path, which crossed the west of London from south to north, has been determined with great care by Mr. A. King, who has utilised all the available observations. The meteor became visible when it was about 60 km. south of Hove and 106 km. up. It did not attract much attention in the early part of its course but from a boat at anchor, near Worthing pier, it was seen to pass nearly overhead, slightly to the east. By the time the meteor passed over London it had become very conspicuous. It seems to have been most brilliant in the neighbourhood of Hatfield where it was bright enough to throw sharp shadows. Mr. King places the point where the meteor broke up as 2 km. north of the centre of Hitchin and 22½ km. up. This point is a little south of the village of Holwell, which is shown on our map. The colour of the meteor when overhead was bluish green; it looked more yellow when seen at a low elevation. When the meteor broke up the fragments appeared to be projected forwards. No trail of glowing matter was left to show where the meteor had passed.

Any expectation that the sound of the meteor was due to a great explosion at the end of its path was dissipated directly the observations were plotted on a map. No sound was heard to the north of the end point and indeed people right beneath that point heard nothing. The area of audibility spread out fanwise, the boundary being almost straight from Reading to Hitchin and from Braintree to Hitchin. In many places the sound was very strong right up to the boundary. South of the Thames the sound was heard at Richmond and at various places in south-east London. There was a group of observations near Dorking beneath the track of the meteor, more isolated observations were at Nutfield and Tonbridge to the east of the track. Well to the west were three good observations at Alton, in Hampshire, and, on the line between Alton and Reading, the sound was heard at Winchfield and Bramley.

The character of the sound varied considerably. At some places, including the southernmost,* there was a single boom or crack. Places with a double or triple report, boom-oom-boom, were common. Three accounts from Reading agree in mentioning a double report. Other places south of the Thames in the same category were on the roads from Leatherhead to

* A rumble as of distant thunder was heard by a motor cyclist between Uckfield and East Grinstead, but the short interval after the passage of the meteor (1 min.) makes the relevance of the observation doubtful.

Dorking and from Sevenoaks to Tonbridge. In Middlesex the sound was comparable to a short peal of thunder gradually falling off in intensity. One report speaks of the sound of a beaten drum rolling over the sky. Such a prolonged sound was noticed, however, as far south as Titsey Hill on the North Downs



THE METEOR of OCT. 2, 1926, 19H. 27M. G.M.T.

∴ The track is shown by the Arrow: audibility by dots.

"a distant roar like a train going over a bridge." Observers near the end of the track compared the noise with machine-gun fire.

In some places, at any rate, there was an "infra-sound" wave. Disturbances such as the rattling of windows were noticed even by people who did not perceive any direct sound. Animals and especially pheasants were disturbed. The pheasants were

affected at Bury St. Edmunds, well outside the region of audibility.

It is curious that on the north-west the boundary of the area over which the meteor was heard runs the length of the Chiltern Hills. Some light on this phenomenon, the sharp boundary of the area of audibility, may be thrown by the report from Mr. A. Jelley, who was at Aldbury, in a valley near Tring, and heard a noise which lasted at least two minutes. "There was a rumbling noise like thunder in the distance, it seemed to start in the south-east of the village, rumbling along the hills, then a pause for a second, then it seemed to rumble back again from where it started, then a faint rumbling northward again, each time fainter. It seemed to be just behind the hills."

When I undertook this enquiry I had not considered closely how the sound of a detonating meteor was likely to be produced. I accepted the idea that the noise came from an explosion. The reports about the Yorkshire meteor convinced me that the thunder-like noise was produced by the mere passage of the meteor through the air; the reports of the meteor of October 2nd suggested that the sharp detonation itself had a similar origin. I find that in both these conclusions I had been anticipated by Dr. Alfred Wegener who investigated* very fully the case of a daylight meteor which fell in Germany on April 3rd, 1916. Wegener points out the analogy with the noise produced by the passage of a shell fired from a big gun. It is well known that a projectile moving through the air with a velocity exceeding that of sound makes a wave like the bow-wave from a ship. This wave when it reaches an observer is heard as a sharp crack. The crack is followed by a rumbling noise which may be attributed to the irregularities in the aerial disturbance. The nature of these ballistic waves is expounded at length in a recent work† by Professor Ernest Esclangon, the pioneer in sound-ranging, the art of locating hostile guns by timing the arrival of the sound at different points. Esclangon attributes the sound of meteors to ballistic waves, though it appears that he has not studied any accounts of observers. One remark†† of his is worth quoting. If the bolide is very small a single detonation should be perceived; otherwise two or three detonations might be heard, as happens with projectiles.

In the case which Wegener investigated the meteor's path was inclined to the vertical at a comparatively small angle, about 35°, and the sound was heard on all sides. In our case the path was much less steep. It seems clear that as the meteor approached

* Schriften der Gesellschaft zur Beförderung der gesamten Naturwissenschaften zu Marburg, 14 (1917).

† L'acoustique des canons et des projectiles, Paris, 1925.

†† loc. cit., p. 82.

the end of the path the intensity of the noise fell off rapidly. The accounts of a sound like machine guns suggests the possibility that when the meteor broke up into bits each produced its own little ballistic wave. In that connexion Professor Lindemann tells me that he explains the fracture as due to centrifugal force. The meteor is bound to get up a spin as it goes through the air and this spin may be accelerated until the relative velocity of the opposite sides is comparable with the velocity of translation. No material could stand the enormous stresses set up by the centrifugal force and the meteor would burst. Probably in most cases the meteor is melted or evaporated before this can take place. Ours seems to have lost a great deal of its mass before the end. It will be noticed that the fracture is not like an explosion in which a quantity of gas is suddenly generated; the fracture can not produce a great sound wave.

As to the original object of the enquiry I have to thank numerous correspondents for the trouble they took to make good estimates of the time that elapsed between sight and sound. In several cases observers retraced their steps, watch in hand. The results obtained in this way are not very consistent however. Fortunately, there were two observers who were able to give within a few seconds the times of the two observations.

Dr. H. B. Heywood, who was at Headstone Lane, Harrow, made the times 8h. 27m. 0s. and 8h. 29m. 15s. Thus the time the sound took to reach his position was approximately 135 seconds. Dr. Heywood gives 10 seconds as a liberal estimate of the possible error in timing the interval. Utilising Mr. King's data and finding from the map that Headstone Lane is 43 km. from the end of the meteor's path we can compute the distance of the meteor track from Dr. Heywood's position. This turns out to be 38 km., and the nearest point of the track was 35 km. above ground. Thus it appears that the average speed of the sound, if it went the nearest way from the track to the observer, was 282 metres per second. The velocity of sound at the freezing-point is 331 metres per second, so Dr. Heywood's observation implies very cold air aloft. In fact, if we take likely values for the temperature up to 20 km. we find for the average temperature between 20 and 35 km. 136°A., *i.e.*, −215° F. This is hardly acceptable, but we note that if Dr. Heywood's estimate of the time is reduced by 10 seconds the mean speed of the sound becomes 304 metres per second and the average temperature between 20 and 35 km. becomes 215° A., *i.e.*, −72° F., and this is quite plausible.

Another observer, Mr. A. Colebrook, gives the times he noted at Reading, 8h. 27m. 4s. and 8h. 32m. 2s. The interval in this case was 298 seconds. If the sound came from the nearest

point of the track the speed averaged only 218 metres per second. Reading is a long way to the west of the track and the only likely explanation of this very low apparent velocity of the sound is a strong adverse wind in the upper regions.

The first point on its course at which the meteor was heard was near Leith Hill. The height of the nearest point of the path was about 50 km. This is interesting as Mr. Denning has recently announced* that by examination of the records of the last 70 years he has found from 90 good instances of detonating meteors, that the average end-height was 33 km. and that there were only four above 55 km. The sound-limit for audible detonations seems to be about 55 km. If we adopt Wegener's theory, we can hardly suppose that there is no ballistic wave at greater heights. Possibly there is a discontinuity which reflects sound waves at that level. The fact that sounds can reach the earth from the height of 55 km. has a bearing on the theory of the transmission to great distances of the sound of explosions. If a sound originating at that height can be heard on the ground, the air at the same height must be dense enough to transmit waves originating on the earth. Further, we note that Dr. Heywood's observation will not allow us to bring much below 35 km. the upper region in which a high velocity of sound prevails. This result is consistent with deductions from the study of the audibility of explosions.

In conclusion, I wish to thank very warmly the numerous correspondents who were so good as to write to me with regard to one or other of the two meteors of September 6th and October 2nd. I regret that it has not been possible for me to reply personally to all the letters. I am especially grateful to Mr. A. C. Armitage, of Letchworth, and Mr. B. Tayor, of Pirton, as well as to Mr. A. C. Denning and Mr. A. King for their co-operation.

Official Publications

The following publications have recently been issued :—

British Rainfall, 1925.

The volume is a summary of the rainfall observations made during 1925 by some 5,000 observers throughout the country.

The rainfall of the year 1925 over the British Isles taken as a unit, was very slightly above the average and from this point of view the year's rainfall can be described as normal. When smaller areas or shorter intervals of time are considered, however, abnormalities become apparent. The most remarkable features of the year were (1) the exceptionally dry June which was absolutely rainless in many localities and one of the driest months on record for the British Isles as a whole ; (2) the cold and cheerless summer, being the fourth summer in succession

* *The Observatory*, October, 1926, p. 314.

of that nature ; (3) the small number of days with heavy falls of rain in spite of the large number of thunderstorms, especially in May and June ; and (4) the wintry conditions which were experienced in the north of Scotland in the early and late months.

Three articles on various branches of recent rainfall research are also included in the volume.

GEOPHYSICAL MEMOIRS.

No. 31. *Classification of monthly charts of pressure anomaly over the northern hemisphere.* By C. E. P. Brooks, M.Sc., and Winifred A. Quennell. (M.O. 286*a*).

In order to have available material for the study of variations of the pressure distribution from month to month, charts were drawn showing the distribution of pressure (deviations from normal) over the northern hemisphere for each month of the years 1873 to 1900 inclusive, which with the addition of the charts for the years 1910 to 1918 previously constructed from the "Réseau Mondial" data, gave a collection of 444 monthly charts. For convenient reference some form of index was desirable, and the classification described in this memoir was devised for that purpose. The classification refers mainly to the conditions over north-western Europe and the north-eastern Atlantic, and especially the area Greenland-Scandinavia-Azores. The pressure at Thorshavn (Faeroes) in the centre of this triangle is taken as the main basis of classification, two groups being defined, in which this pressure is respectively above and below normal. The further classification depends upon the positions of the centres of excess and deficit of pressure. Each of the types and sub-types is illustrated by charts representing an impressionist synthesis of the various examples classified as belonging to that type.

A table showing the classification of each monthly chart is given and from this table the frequency and sequence of types are calculated. The greatest number of charts fall into the types where the excess or deficit is centred over Iceland. There is very little indication of any regular sequence of types ; the most noteworthy is that type IIC (centre of deficit over British Isles) in winter tends to be followed by type I. (pressure above normal at Thorshavn).

Discussions at the Meteorological Office

November 8th. *Temperature Variations in the Stratosphere.* By R. Mugge (Met. Zs. XLII., 1925, pp. 389-394). *Opener*—Mr. E. Taylor, M.A., B.Sc.

To account for the relatively low temperatures found in the upper troposphere and stratosphere over warm high pressure areas occurring in our latitudes, the author considers three points of view, viz., advection, dynamic causes, and radiation.

The temperatures of the stratosphere and substratosphere

decrease as the temperature of the lower strata increases, whether we consider variations at one and the same place in our latitudes or variations of temperature gradient with latitude. Pressure gradient and its fluctations with altitude and latitude follow a similar law. Just as in the lower strata, fluctuations of temperature and pressure are often causatively connected and can then be traced to simple advection phenomena, and in particular to incursions of the polar front, so the low temperatures associated with the upper strata of warm high pressure areas may be due to inrushes of the upper cold equatorial front. This is supported by evidence of frequently occurring inversions at the stratosphere boundary which may be attributed to under-running of the stratosphere layers by a cold current from the south.

The author's chief objection to this explanation is that warm high pressure areas exhibit a persistence more marked than that of any other weather phenomena in our latitudes, a persistence which would entail a continuous inflow of cold equatorial air to replace the air which sinks for days at a time over such regions.

In 1921 he and Peppler separately decided from upper air soundings that the upper strata of at least some high pressure areas have a single divergence point about which wind and pressure is distributed ; therefore some of these areas at least must be regarded as "Islands of Cold," and the cause of their maintenance must be sought elsewhere than in the equatorial front. A high pressure area established by a limited inrush of equatorial air would have a mobility comparable to that of the cold polar front anticyclone.

The possibility of a dynamic cause for low temperatures prevailing locally in high reaching anticyclones is dismissed very briefly. The theory which Bjerknes and Sandström have advanced for a warm anticyclone is not in good agreement with observations. Though a discontinuity probably exists at the base of the sinking air mass the latter cannot be considered as a symmetrical rotating eddy. Purely dynamical elevation of the troposphere due to heating of the lower strata is a possible cause in tropical regions but not in middle latitudes ; and in tropical regions it would involve the presence of an extraordinarily strong inversion.

Turning to radiation theory for an explanation, the author refers briefly to the work of Gold and Humphreys, and remarks that for high altitudes where the dependence of temperature on altitude disappears, it leads to the simple formula

$$T = \sqrt[4]{\frac{J}{2\sigma}(1+q)}$$

in which T is the temperature of radiative equilibrium, J is the effective intensity of radiation, a function of solar radiation and

the earth's albedo, σ is the constant of the Stefan-Boltzmann law and q a value expressing the ratio of the two coefficients of absorption for short and long waves.

When the variation of J with latitude is taken into account, this equation gives values of T low at the poles and high at the equator; for example T becomes —40° C. (approx.) at the equator. Actually it is observed to be nearer —80° C. This difference between theory and observation is due to the assumption in the theory that incoming and outgoing radiation are equal over any one region of the earth's surface, whereas in fact such equality is seldom found. For the polar and equatorial regions and likewise for warm high pressure areas with their marked thermal characteristics such equality is never to be expected. On these grounds the author has distinguished between regions of incoming and regions of outflowing radiation ("incoming" and "outflowing" denoting the sense of preponderating radiation). The former are important potential energy accumulation centres which yield up heat to the latter. Warm anticyclones are classed among the regions of incoming radiation. This classification has also been adopted by Defant.

The next step is to adapt the equation given above to fit the argument by writing

$$T = \sqrt[4]{\frac{J}{2}(1+q) - \frac{R}{2\sigma}}$$

where R denotes the proportion of radiation energy acquired or dissipated as the result of thermal processes in the troposphere in the two types of region. The temperature corresponding to $R = 0$ is called the normal stratosphere temperature.

As a rough example of the way this modification would operate, it is shown that a quantity of energy $R = +0{\cdot}08$ calories per square centimetre per minute would have to be withdrawn from the region between the equator and latitude 40° to account for observed mean values of T in that region. Differentiating broadly between this region as one of incoming radiation and the remainder of the hemisphere as one of outflowing radiation and assuming that the heat withdrawn from lower latitudes is transferred to the latitudes above 40° across a wall of the troposphere extending vertically to 4 kilometres, the author finds that the heat transference would be at the rate of 100 calories per square centimetre per minute, a quantity whose order is in agreement with Defant's work.

The paper includes a graph showing in parameter form the relation between the three quantities T, J and R.

The title of the paper suggests a wider range of investigation than is covered by the text but a more detailed analysis of heat transference from warm anticyclonic regions is to appear later.

In view of the hypothetical nature of the present paper and the fundamental question raised, it will be interesting to see the result of applying the suggested modification of the radiation theory to particular areas for which actual values of J and T can be stated with some measure of accuracy.

E.T.

The next meeting will be held on January 17th, when Dr. B. A. Keen, of Rothamsted, will open the discussion on some subject relating to agriculture and meteorology.

Royal Meteorological Society

The monthly meeting of this Society was held on Wednesday, November 17th, at 49, Cromwell Road, South Kensington, Sir Gilbert Walker, C.S.I., F.R.S., President, in the Chair.

E. W. Bliss, M.A.—The Nile Flood and World Weather.
See page 268.

D. Brunt, M.A., B.Sc.—An Investigation of Periodicities in Rainfall, Pressure and Temperature at certain European stations.

This paper gives a discussion of twelve periodograms ; those of rainfall at Milan, Padua, London and Edinburgh, of pressure at Edinburgh and Paris, and temperature at Edinburgh, Stockholm, London, Paris, Berlin and Vienna, which were published in *Phil. Trans. R. Society*, Vol. 225, 1925. The author does not advocate their use for forecasting future weather.

D. Brunt, M.A., B.Sc.—A simple period of vertical oscillation in the atmosphere.

This paper shows that when an element of air is displaced vertically it oscillates harmonically about its equilibrium position with a period of the same order as those found in microbarograph records.

Correspondence

To the Editor, *The Meteorological Magazine*

The Last British Glacier

I do not suppose there is anybody who thinks that ice is still scratching the rocks in the British Isles, but I am by no means sure that such is not the case. The site in question is usually snow covered all the year. Thinking that in 1918 the snowbeds would be smaller than usual, I went to explore some that I know of. The rocks then seen may not have been exposed to the light for ten years, perhaps 50, I have no means of knowing. They were worn absolutely smooth and were brown or yellow

in colour, totally different to any other rock. The snow bed had got so small that it had split into four isolated pieces, about 4 feet thick, the under surface practically pure ice. Below the bed is a heap of scree pushed down by the bed or falling from its extremity. As the bed in April or May must be 50-100 feet in thickness and lying on steep rock there must be some downward pressure after the nature of a glacier. It is probably the remains of the last glacier in Britain.

I believe the snow beds were very small this year but I was not able to go and see them; anyhow the coldness of October must have quickly increased them as Ben Nevis was snow clad to 2,000 feet at the end of September.

These beds are not on Ben Nevis but on Aonach Mt. some three miles or so east and are due to Aonach Mt. having a flat top so that all the snow (practically) blows off it and down the cliffs. Much the same thing happens on Brae Riach (Cairngorms) only far more so, as the plateau at the summit is far more extensive, but against this is the smaller precipitation in Cairngorms. Nevertheless, the Brae Riach bed has never been known to melt, the drifting area and height of same (4,000 feet) being so enormous. I have never been to this bed though I saw it in 1918 from the cliffs above. It was my first visit there. I looked for it in the many corries, then went to the summit of the plateau and only saw it from there. There was no time to descend to it. Mr. Seton Gordon paid a visit to it in mid-September last and wrote me that it was smaller than he had ever seen it and thought it might disappear, but as cold weather supervened at the end of September I don't think it did.

In addition to the two beds on Aonach Mt. there is a third about a mile from the two I have spoken about; I had found this before 1918 but it looked rather small and I thought it might not be permanent, so that in 1918 when I found one of the beds gone and the other reduced to four slabs I was surprised to find this third one still existing. It is under Aonach Beas.

R. P. DANSEY.

Kentchurch Rectory, Hereford. November 4th, 1926.

[The photograph is not reproduced, as it is doubtful if a reproduction would show the details of the original with sufficient clearness. There is a typical smoothed glacial surface, ending in a loose moraine of the kind formed by small mountain glaciers. Some light and dark bands on the smoothed surface may represent either flutings and striations or colour bands in the rock itself.

It does not seem probable that the extensive planation of the rock surface can have been effected by the small masses of ice which are able to survive the summer at present. The smoothed surface seems to extend beneath the scree and probably dates

back to the maximum glaciation of Great Britain, when the whole mountain was submerged beneath an inland ice-sheet which reached to the sea on the east, west and north, and on the south extended into England. During the retreat of the ice-sheet the Scottish mountains formed nunataks and the glaciated surfaces were probably covered by screes. In subsequent cold periods mountain glaciers were formed which cleared away this scree in places and exposed the underlying glaciated surface, and the "moraine" shown in the photograph presumably represents the last and least intense of these minor glaciations. It is quite possible that it originated as late as the eleventh to fourteenth centuries A.D. The snow and ice bed which is formed at present each winter and generally persists through the summer would be quite capable of keeping this smoothed surface clean and unweathered.—ED. *M.M.*]

The "Sticking" of Pressure Tube Anemometers at Low Wind Velocities

In the *Meteorological Magazine* for July, 1924 (p. 132) a suggestion is given for preventing the "sticking" of the float rod in the pressure tube anemometer. This "sticking" is caused by the condensation upon the float stem of the water vapour given off from the water surface around the float. The extent to which this evaporation and condensation go on can be judged by removing the lid of the recorder, when it will nearly always be found that the underside of the lid is covered with large pendulous drops of water, and the walls of the container are literally running with water.

It occurred to me about a year ago that the most effective way of preventing the condensation would be to prevent the evaporation. The most obvious way of achieving this appeared to be by covering the water surface with a thin layer of non-volatile oil. One of our pressure tube recorders was treated in this way, the annular water surface between the float and the walls of the container being covered with a thin coating of a high boiling point paraffin. The oil in question is a pure (B.P.) paraffin of the type used medicinally. This instrument has been working for over a year since being treated in this manner, and it has been found that the "sticking" of the float stem has been reduced to vanishing point. Incidently it has also been found that it is best to keep the float stem highly polished.

It subsequently occurred to me that covering the water surface inside the float with oil would prevent the distilling over of this water and its gradual collection at the lowest point of the pipe which transmits the pressure from the head. Our instruments are now erected by covering the entire water surface

with oil before the float is put into the container. The addition of the oil necessitates, of course, running off some of the water so as to bring the level down to the top of the style in the gauge glass on the side of the instrument. It may be noted, incidentally, that the presence of the oil prevents the change in level of the water surface which normally occurs in these instruments.

The effect of the addition of this oil upon the calibration of the instrument has been investigated, and I am indebted to Mr. R. F. Budden for the following figures. The recorder was calibrated in the usual manner by means of a tilting manometer of the National Physical Laboratory type, which showed the pressure necessary to raise the float to ten, twenty, thirty, etc., feet per second on the chart. This was done for three cases, as shown in the following table :—

Recorded Wind Speed in ft./sec.	Observed Pressure Differences in millimetres of Water.		
	No Oil.	Oil in Suction Chamber only.	Oil in both Chambers.
10	0.7	0.7	0.7
20	2.9	2.7	2.5
30	6.7	6.7	6.5
40	13.2	12.3	11.9
50	20.4	19.5	19.5
60	29.6	28.5	28.5
70	40.8	39.8	39.5

It will be observed that the addition of the oil makes a small, but appreciable, difference in the calibration. For a given pressure difference the recorder reads about one foot per second higher if the entire water surface is covered with oil. When only the water outside the float is covered, the increase in the reading appears to be rather less. These differences are smaller than the variations which are found to exist between individual pressure heads. It may, therefore, be concluded, that the addition of the oil does not affect the reading of the instrument for ordinary purposes, but that if a high degree of accuracy is required the recorder should be calibrated after the oil has been added.

The treatment described above does not, of course, prevent "sticking" in those cases in which it is due to condensation from the atmosphere upon the protruding part of the stem. But these occasions are rare compared with those which arise from evaporation and condensation inside the instrument.

N. K. Johnson.

Experimental Station, Porton, Salisbury. October 19th, 1926.

NOTES AND QUERIES

Early Experiments in Measuring the Upper Wind by means of Shell-Bursts

The method of obtaining the wind at high altitudes by observations of smoke clouds produced by the bursting of shells fired from high angle guns was used extensively during the war. It is the best method known for getting the wind at high altitudes in a broken sky or windy weather. Although I do not know of any specific claim being put forward that the method was a new one, I myself had always regarded it as a natural war-time development of the observation of cloud motion and I had not been aware of any earlier use of the method. I was therefore very interested to come across a reference to experiments on this method in the *Minutes of the Proceedings of the Meteorological Council* 45 years ago. I thought it would probably be of interest to many others also and I therefore obtained authority to make use of the information contained in the Minutes.

The story of the experiments as given in the *Proceedings of the Council* for the year **1881-5** is briefly as follows:—

At the meeting on July 20th, 1881, Mr. Galton (Sir Francis Galton) mentioned that he had made enquiries of Captain A. Noble, C.B., F.R.S. (Sir Andrew Noble) "on the possibility of forming a smoke cloud at a considerable altitude for the observation of upper air currents by firing a small shell, with a bursting charge, from a seaside station, that the plan seemed to be feasible, but that preparative experiments were needful to determine the best method of forming a dense and durable smoke cloud."

The Council decided to authorise Mr. Galton, in conjunction with Captain Noble, to expend a sum not exceeding £20 on the experiments.

In February, 1882, Captain Noble reported that he had made experiments with a light 7-pounder gun of 400 lb. weight, mounted at an angle of 75°, which was the highest angle considered safe, from the point of view of those using the gun, in the event of a premature explosion. In the first experiment, the shell burst after $2\frac{1}{4}$ seconds, the height of the burst being roughly estimated at about 2,500 feet. The second round burst at 5·35 seconds, but the third, fourth, fifth and sixth rounds, although they burst and their bursts were seen, were not observed at the moment of burst.

An attempt was made to obtain the height of the bursts by means of two observers taking the angle at the moment of the burst, but the great difficulty of making the two observations simultaneously caused this attempt to be a failure.

Further experiments were made on January 5th, 1882, but no attempt was made on this occasion to measure the height by

observation of two angles. The height was determined by noting the time between the burst and the sound of the report and taking the angle of elevation of the burst observed from the gun. Three very good observations were made of the time taken by the sound to return to the gun. They were 9·7, 9·8 and 9·8 seconds. The angle of the elevation of the burst was 62° in all three cases and these data gave for the height of the burst approximately 9,500 feet. Captain Noble remarks " the day was exceedingly windy but the sky very clear. A cloud of smoke could be seen without difficulty for a considerable time but I should anticipate great difficulty in seeing it in a dull leaden sky. There would be no difficulty with a larger gun in sending the shell very much higher, but the expense would be very much greater."

On receipt of Captain Noble's report, the Meteorological Council instructed the Secretary to enquire whether it would be possible to have a series of observations made with the gun at Shoeburyness (the experiments of Captain Noble had been made at Elswick Works, Newcastle), and if so whether an attempt could be made to determine, at the time when each round is fired, the direction and the velocity of the upper wind by observation of the bursting of the shell and of the subsequent course of the smoke.

The Council at the same time indicated that they were prepared to increase the amount of the grant for the experiments.

In reply to the Council's enquiry, Captain Noble stated that he was satisfied there would be no difficulty in having a series of observations made at Shoeburyness, that his firm would be happy to lend the gun and carriage for the purpose and that he himself in concert with Mr. Galton, would be happy to assist at the experiments. The sanction of the War Office to the experiments was duly obtained but so far as I can ascertain, they were never actually made at Shoeburyness.

Some further experiments do however appear to have been made, for Captain Noble reported in March, 1884, on further observations apparently with the same gun on August 23rd, 1883. The bursts appear to have been visible for several minutes, and in his report he gives two sketches showing the direction of travel of the smoke puff in relation to the direction of the wind, but no actual observations of the speed of the bursts. The height of the bursts appear to have been between 8,000 and 10,000 feet.

The Council considered this report and instructed the Secretary to write to Captain Noble asking him if he could arrange for a three months' course of observations carried out at Elswick or elsewhere under his general superintendence by competent men, the Council bearing the cost and allotting a grant beforehand to

cover it. The observations were to be made within half-an-hour of 8 a.m. and to give the angular elevation of the burst of the shell, the direction of the drift of the smoke cloud, the interval in time between the burst and the sound of it and the angular velocity of the smoke cloud. If the results of such a trial proved to be favourable they would wish to be informed of the cost of purchasing the gun, carriage and gear and the cost of the shells, etc., connected with firing, say, per 100 shots.

There is no evidence of any reply having been received to this communication and the matter appears to have been dropped. As it depended mainly, I think, on the initiative of Sir Francis Galton, the fact that nothing more was done may have been due to his energies having been diverted into other channels.

E. G.

Two Memoirs on World Weather: The Nile Flood, and British Winters*

The first memoir is an application to the Nile of the methods which have been used in India by Sir Gilbert T. Walker. The series of values for the Nile flood are based on the discharges at Aswan and the total for the four months July to October is taken to represent the flood. A considerable amount of secular change is apparent in the series, but as far as I know it cannot be ascribed to the presence of the Dam which is fully open during flood, or to erosion of the river bed.

The following conclusions are drawn from the correlation coefficients. First, the Nile behaves as a strongly marked member of the first group of the southern oscillation, *i.e.*, it has positive correlations with South America and Pacific Ocean pressures and negative with pressures over the Indian Ocean. Second, low equatorial temperatures are associated with a high Nile, and third, the North Atlantic circulation in winter is weak after a high Nile. For prediction of the flood, Port Darwin pressure, Samoa and Dutch Harbour temperatures may be used and from its coefficient of ·72 the formula may be expected to give useful indications in 40 per cent. of the years: in the other years when the indicated departure is small no forecast would be attempted.

It was mentioned that the Nile shows a secular change and as some of the other factors undergo similar changes, it is of interest to examine the effect of this on the coefficients. Taking Port Darwin pressure in which there is a marked rise I found on eliminating secular changes that instead of $-·54$ the coefficient became $-·45$.

It may be of interest to note that the probable deviation of the

* *London, Mem. R. Meteor. Soc.*, Vol. I. Nos. 5 & 6.

Nile flood is 10,000 million cubic metres; departures are as likely to exceed as to be less than this amount.

The second memoir deals with the winter temperature of Greenwich. In view of its connection with the Nile further correlations were worked out with the Greenwich temperature of December to February. It appears that during the previous June to August conditions in the tropics and the southern hemisphere exert a considerable control on the subsequent winter temperature in the British Isles. Within the northern hemisphere, however, the relationships are mainly contemporary ones but an interesting point is that while winter and spring in the British Isles are interrelated, there is no connexion between autumn and winter temperatures. This bears out a result of W. Wiese, who shows that with October a new "meteorological year" begins.*

Although there are not so many large coefficients as were found in the former memoir there are as many as seven between ·42 and ·54 which relate to prior conditions; and it would appear that some advance has been made towards the solution of the problem of forecasting in September or October the mean temperature of the winter months in England.

E. W. Bliss.

The Wet November of 1926

The distribution of the rainfall of November, 1926, presented some features of unusual interest.

The total for the month was above the average everywhere over the British Isles except along the north-west, north and north-east coasts of Scotland. The excesses were largest in the south-west of England and Wales and in Connemara. More than twice the average was recorded in these areas as well as at Wetherby in Yorkshire and at Dundee. Falls of more than 250 per cent. of the average occurred in parts of Dorset, Hampshire and Hereford, while at Ross, the fall of 7·87 in. was as much as 311 per cent. of the average. It appears to be a feature of the climate of Herefordshire that the variability of monthly and of annual rainfall, when considered as a percentage of the average falls, is generally larger than that experienced elsewhere in the British Isles.

There were large areas with over 10 inches of rain for the month in Dartmoor, Exmoor, the English Lake District, Wales, the Western Highlands of Scotland and also in Connemara. The largest monthly totals were those reported from Llyn Llydaw on Snowdon of 19·50 in., and from Delphi in Connemara of 18·30 in. Over five inches of rain was recorded in one day in Snowdonia on the 4th and in Connemara on the 18th.

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* *Met. Zs.*, June, 1926, p. 215.

Many observers reported the wettest November on record. At stations as widely distributed as Camden Square (London), Polapit Tamar, near Launceston, to the west of Dartmoor, and at St. Michael's on Wyre in the north of Lancashire, the total for the month was the largest for November in over 50 years' records. At Camden Square the number of days of rain, *viz.*, 25, and the duration of rainfall of 85·0 hours were the largest in November since records became available in 1858 and 1881 respectively.

So far as can be ascertained at the moment, November, 1926, was the wettest November since 1870 over England and Wales, and also the wettest November over the British Isles as a whole. The rainfall of Scotland and Ireland was less remarkable. A comparison of the general rainfall over the British Isles for November, 1926, with the three wettest Novembers back to 1870 is set out below. The rainfall is expressed as a percentage of the average amounts for the period 1881 to 1915.

November of	1926	1888	1877	1872
	%	%	%	%
England and Wales	188	175	162	162
Scotland	130	139	153	144
Ireland	137	121	143	145
British Isles	163	153	155	153

For the eleven months, January to November, 1926, the rainfall at Camden Square has amounted to 26·80 in. This is 4·72 in. above the average of the eleven months and already 2.33 in. above the average for the whole year. For the British Isles as a whole, the general rainfall for the eleven months is estimated as 41 in. This is 4 in. above the average for that period and only about half an inch below the average for the whole year. It is clear therefore that while the rainfall of the whole year over the British Isles generally may not rank as very heavy it will almost certainly exceed the average.

J.G.

The Rainfall of Novembers

With the wet November of 1926, it is of interest to consider extremely wet and dry Novembers in comparison with the extremes experienced in other months. A marked feature of the rainfall of Novembers in these islands is the smaller variability than that of other months, the variability being considered not in actual inches but as a percentage of the average. This can be illustrated by reference to the table below giving the wettest and driest months for the British Isles as a whole from 1870 to

1925. The values for each month have been obtained by taking the mean of the percentages for some 50 stations distributed uniformly over the British Isles.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Per cent.	192	204	171	172	187	196	176	183	242	193	155	189
Date ..	1877	1923	1903	1882	1924	1879	1888	1917	1918	1903	1877	1876
Per cent.	37	18	34	35	26	21	39	38	33	44	43	41
Date ..	1880	1891	1893	1893	1896	1925	1913	1880	1910	{1879, 1922}	1896	1890
Range ..	155	186	137	137	161	175	137	145	209	149	112	148

In the last row the range is obtained from the percentage fall in the wettest month and the percentage fall in the driest month. It will be seen that the months of greatest range are February and September. Both these months have been conspicuous for long runs of rainless days and also for consecutive wet days over large areas in these islands. November on the other hand stands out as the month of most reliable rains, the wettest and driest Novembers in the series being considerably nearer the average fall for November than is the case with the other months. The months of 1926 have so far not changed the table of extremes above, except in the case of November. Even with this modification the range for November is still considerably below that of the other months.

J.G.

News in Brief

The degree of D.Sc. (Physics) has been conferred by the University of London on Mr. C. E. P. Brooks.

Further information is now available as to the course of the hurricane during which the H.M.S. *Valerian* foundered off Bermuda. The Government meteorologist states that it appeared to the north of Colon on the 17th, and followed a north-west track across western Cuba, causing great loss of life round Havana on the 20th.

The Weather of November, 1926

Mild unsettled conditions with southwesterly winds and a rainfall abnormally heavy were the main characteristics of the weather of November. At the beginning of the month fine weather and low temperatures prevailed generally over the eastern part of the British Isles, the lowest minimum for the month occurring on the morning of the 1st when 9° F. was

recorded in the screen at Balmoral and 1° F. on the grass. On the 2nd, however, the depression in the west spread eastwards and from then until the end of the month pressure continued low. The mean pressure for the month was considerably below normal at most places, and at Valentia it was about 2 mb. lower than the previous record in November, 1877. Temperature rose generally about the 5th when a deep depression passed across the Hebrides causing southwesterly gales in many places. Gusts of over 80 m.p.h. were recorded at Edinburgh and Quilty, and rainfall for the 24 hours ended 7h. that morning was heavy, 137 mm. (5·40 in.) being measured at Snowdon, 83 mm. (3·28 in.) at Dungeon Ghyll (Westmoreland), and 73 mm. (2·87 in.) at Eskdalemuir. Floods occurred in many parts of Scotland and Wales, and " snow lying " was reported from the extreme north. From the 8th to the 22nd unsettled conditions prevailed with rain on most days and high winds or gales frequently. At Plymouth a gust of 80 m.p.h. was registered on the 10th. The heaviest rain occurred on the 18th when 129 mm. (5·06 in.) fell at Delphi (Mayo), and 105 mm. (4·12 in.) at Aasleagh (Mayo), but measurements of over 50 mm. were recorded on other days at many places. Floods occurred in several districts. Thunderstorms and hail showers were also experienced fairly frequently throughout this period. During the last week a deep depression which had passed across our islands filled up over the North Sea and pressure became temporarily high over England on the 24th and 25th. Widespread fog occurred in southern Scotland on the 24th and in England on the 25th. Temperature did not rise above 32° F. at Renfrew on the 24th and 33° F. at Croydon on the 25th. There was a return to generally unsettled rainy conditions on the 26th, and on the 29th a depression centred over the English Channel caused heavy rain in the south. Meanwhile a belt of high pressure extending from Norway to the Azores was moving southeast and fair weather prevailed in Scotland and north Ireland on the 29th and 30th.

The total rainfall for the month is discussed on p. 269.

Pressure was below normal over a large area, stretching from central Europe and the Baltic across the North Atlantic to Greenland and Labrador, the greatest deficit being 13·7 mb. at Valentia, and above normal at the Azores, south Italy, Spitsbergen, and the extreme north of Norway. At Horta pressure was 6·7 mb. above normal. This distribution was associated with the frequent passage of depressions across these islands and with generally southwesterly winds over western Europe. Temperature and rainfall were both above normal, except in central Europe and the south eastern coastal districts of Sweden, where the rainfall was somewhat below normal. In Norrland

and northern Svealand the precipitation was about double the normal.

During the first days of the month heavy rain accompanied by floods occurred in many parts of Italy and Westphalia, and a severe hailstorm was experienced in Corsica. On the 9th a thunderstorm swept over western Switzerland causing much damage to forests and orchards, and later in the month several lives were lost in Murcia (Spain) owing to the heavy rains and floods. In the meantime a sudden thaw in the mountains south of the Tyrolese Alps, caused much damage, and the weather in the Austrian lower Alps was so warm that strawberries were gathered in the open on the 16th. In Greece the prolonged drought gave rise to much anxiety with regard to the crops. During the later part of the month very stormy weather was again experienced in France, Italy and Switzerland, and floods occurred in many parts. An avalanche of mud and rock caused by the heavy rains overwhelmed the village of Roquebillière, near Nice, on the 24th, and nineteen people were killed. In consequence of a drop in temperature and the heavy snowfalls winter sports began in the higher resorts at the end of the month.

Heavy rain occurred in the Transvaal about the 20th to 27th putting an end to the bad drought, during which the farmers have lost many cattle and sheep through the drying up of the veld.

Unusually heavy and early rain fell in Iraq' about the middle of the month promising a good season but causing much damage to the railway lines. Three hundred people are reported to have been drowned as a result of a typhoon which crossed the province of Batangas (Philippines) on the 6th.

In the United States a tornado struck a schoolhouse in Laplata, Maryland, on the 9th, killing thirteen children. Storms or blizzards were experienced in many States and on the North Atlantic between the 14th and 17th and again about the 25th, when over 50 people were killed by a tornado which swept across central Arkansas into Missouri.

The special message from Brazil states that the rainfall was very scarce in the central regions, being 56 mm. below normal, and irregular in distribution in the southern regions, with an average 8 mm. below normal. Many depressions passed across the country. The cane, cotton and tobacco crops are suffering from lack of rain, but the coffee crop is in good condition. Pressure at Rio de Janeiro was 0·3 mb. above normal, and the temperature 1·3° F. above normal.

Rainfall, November, 1926—General Distribution

England and Wales ..	188	per cent. of the average 1881-1915.
Scotland	130	
Ireland	137	
British Isles	163	

Rainfall: November, 1926: England and Wales

CO.	STATION.	In.	mm.	Per-cent. of Av.	CO.	STATION.	In.	mm.	Per-cent of Av.
Lond.	Camden Square	4·71	120	200	*War.*	Birminghm, Edgbaston	5·64	143	237
Sur .	Reigate, The Knowle	6·20	157	214	*Leics*	Thornton Reservoir	4·02	102	178
Kent.	Tenterden, Ashenden	7·11	181	236	„ .	Belvoir Castle	3·27	83	147
„ .	Folkestone, Boro. San.	5·80	147	...	*Rut* .	Ridlington	3·36	85	...
„ .	Margate, Cliftonville	4·41	112	183	*Linc.*	Boston, Skirbeck	2·87	73	144
„ .	Sevenoaks, Speldhurst.	7·00	178	...	„ .	Lincoln, Sessions House	2·23	57	119
Sus .	Patching Farm	8·04	204	225	„ .	Skegness, Marine Gdns.	2·43	62	113
„ .	Brighton, Old Steyne	6·76	171	211	„ .	Louth, Westgate	2·87	73	111
„ .	Tottingworth Park	8·42	214	228	„ .	Brigg	2·45	62	107
Hants	Ventnor, Roy.Nat.Hos.	7·72	196	240	*Notts.*	Worksop, Hodsock	2·88	73	147
„ .	Fordingbridge, Oaklnds	10·38	264	303	*Derby*	Mickleover, Clyde Ho.	3·68	93	165
„ .	Ovington Rectory	8·40	213	253	„ .	Buxton, Devon. Hos.	5·80	147	124
„ .	Sherborne St.JohnRec.	...	..	...	*Ches.*	Runcorn, Weston Pt.	5·27	134	190
Berks	Wellington College	4·94	125	193	„ .	Nantwich, Dorfold Hall	5·08	129	...
„ .	Newbury, Greenham	7·13	181	255	*Lancs*	Manchester, Whit. Pk.	4·84	123	183
Herts.	Benington House	4·62	117	195	„ .	Stonyhurst College	5·63	143	125
Bucks	High Wycombe	5·41	137	217	„ .	Southport, Hesketh Pk	5·92	150	188
Oxf.	Oxford, Mag. College	4·29	109	194	„ .	Lancaster, Strathspey.	6·70	170	...
Nor .	Pitsford, Sedgebrook	3·62	92	165	*Yorks*	Sedbergh, Akay	...	..	...
„ .	Eye, Northolm	...	..	...	„ .	Wath-upon-Dearne	2·64	67	129
Beds.	Woburn, Crawley Mill.	3·39	86	152	„ .	Bradford, Lister Pk.	5·82	148	199
Cam.	Cambridge, Bot. Gdns.	2·88	73	149	„ .	Wetherby, Ribston H.	5·09	129	218
Essex	Chelmsford, CountyLab	4·30	109	191	„ .	Hull, Pearson Park	2·80	71	128
„ .	Lexden, Hill House	3·87	98	...	„ .	Holme-on-Spalding	2·92	74	...
Suff .	Hawkedon Rectory	3·29	84	145	„ .	West Witton, Ivy Ho.	6·16	157	...
„ .	Haughley House	2·99	76	...	„ .	Felixkirk, Mt. St. John	4·47	114	182
Norf.	Beccles, Geldeston	2·68	68	115	„ .	Pickering, Hungate	3·40	86	...
„ .	Norwich, Eaton	3·09	79	120	„ .	Scarborough	2·82	72	114
„ .	Blakeney	4·03	102	182	„ .	Middlesbrough	3·37	86	159
„ .	Swaffham	3·81	97	157	„ .	Baldersdale, Hury Res.	5·43	138	...
Wilts.	Devizes, Highclere	6·14	156	231	*Durh.*	Ushaw College	4·18	106	165
„ .	Bishops Cannings	6·34	161	222	*Nor*	Newcastle, Town Moor.	3·58	91	148
Dor .	Evershot, Melbury Ho.	11·06	281	259	„ .	Bellingham, Highgreen	5·66	144	...
„ .	Creech Grange	10·76	273	...	„ .	Lilburn Tower Gdns.	4·20	107	...
„ .	Shaftesbury, Abbey Ho.	7·12	181	220	*Cumb*	Geltsdale	5·47	139	...
Devon	Plymouth, The Hoe	7·67	195	210	„ .	Carlisle, Scaleby Hall	4·32	110	144
„ .	Polapit Tamar	9·11	231	215	„ .	Seathwaite M.	19·03	483	140
„ .	Ashburton, Druid Ho.	12·66	321	223	*Glam.*	Cardiff, Ely P. Stn.	8·84	225	212
„ .	Cullompton	8·32	211	242	„ .	Treherbert, Tynywaun	18·58	472	...
„ .	Sidmouth, Sidmount	8·64	219	277	*Carm*	Carmarthen Friary	11·06	281	222
„ .	Filleigh, Castle Hill	7·98	203	...	„ .	Llanwrda, Dolaucothy.	11·56	294	196
„ .	Barnstaple, N.Dev.Ath.	7·21	183	183	*Pemb*	Haverfordwest, School	11·94	303	238
Corn.	Redruth, Trewirgie	8·90	226	183	*Card.*	Gogerddan	8·71	221	184
„ .	Penzance, Morrab Gdn.	6·41	163	140	„ .	Cardigan, County Sch.	8·25	210	...
„ .	St. Austell, Trevarna	8·58	218	174	*Brec.*	Crickhowell, Talymaes	11·80	300	...
Soms	Chewton Mendip	8·79	223	205	*Rad* .	Birm. W. W. Tyrmynydd	11·07	281	166
„ .	Street, Hind Hayes	6·23	158	...	*Mont.*	Lake Vyrnwy	9·84	250	177
Glos.	Clifton College	7·62	193	242	*Denb.*	Llangynhafal	4·39	112	...
„ .	Cirencester, Gwynfa	7·17	182	234	*Mer* .	Dolgelly, Bryntirion	8·80	224	142
Here.	Ross, Birchlea	7·87	200	311	*Carn.*	Llandudno	4·21	107	136
„ .	Ledbury, Underdown.	6·55	166	268	„ .	Snowdon, L. Llydaw 9	19·50	495	...
Salop	Church Stretton	6·68	170	227	*Ang* .	Holyhead, Salt Island.	6·88	175	166
„ .	Shifnal, Hatton Grange	4·97	126	208	„ .	Lligwy	6·21	158	...
Staff.	Tean, The Heath Ho.	5·17	131	176	*Isle of Man*				
Worc.	Ombersley, Holt Lock.	5·66	144	248		Douglas, Boro' Cem.	5·63	143	120
„ .	Blockley, Upton Wold.	6·21	158	210	*Guernsey*				
War.	Farnborough	4·81	122	176		St. Peter P't, Grange Rd	8·63	219	205

Rainfall: November, 1926: Scotland and Ireland

CO.	STATION	In.	mm.	Per-cent. of Av.	CO.	STATION.	In.	mm.	Per-cent of Av.
Wigt.	Stoneykirk, Ardwell Ho	6·20	157	156	*Suth.*	Loch More, Achfary...	7·06	179	83
„ .	Pt. William, Monreith.	6·16	156	...	*Caith*	Wick	2·45	62	78
Kirk.	Carsphairn, Shiel.	8·89	226	...	*Ork* .	Pomona, Deerness	3·87	99	98
„ .	Dumfries, Cargen.....	8·08	205	179	*Shet* .	Lerwick	4·81	122	113
Roxb	Branxholme	4·35	110	131		————			
Selk .	Ettrick Manse........	9·17	233	...	*Cork.*	Caheragh Rectory	7·46	189	...
Berk.	Marchmont House	3·94	100	131	„ ..	Dunmanway Rectory.	8·36	212	135
Hadd	North Berwick Res....	2·69	68	120	„ ..	Ballinacurra	5·27	134	132
Midl	Edinburgh, Roy. Obs..	3·05	77	142	„ ..	Glanmire, Lota Lo. ...	6·26	159	145
Lan .	Biggar	3·91	99	137	*Kerry*	Valentia Obsy.	8·34	212	153
„ .	Leadhills	9·25	235	...	„ .	Gearahameen	...	..	...
Ayr .	Kilmarnock, Agric. C..	4·94	126	131	„ .	Killarney Asylum.....	7·25	184	129
„ .	Girvan, Pinmore......	5·96	151	112	„ .	Darrynane Abbey	7·64	194	150
Renf.	Glasgow, Queen's Pk..	6·33	161	170	*Wat* .	Waterford, Brook Lo..	5·61	142	148
„ .	Greenock, Prospect H..	8·36	212	130	*Tip* .	Nenagh, Cas. Lough...	5·74	146	143
Bute.	Rothesay, Ardencraig.	6·87	175	135	„ .	Tipperary	...	..	...
„ .	Dougarie Lodge	7·32	186	...	„ .	Cashel, Ballinamona ..	4·34	110	124
Arg .	Ardgour House	10·11	257	...	*Lim* .	Foynes, Coolnanes	5·34	136	131
„ .	Manse of Glenorchy..	9·78	248	...	„ .	Castleconnell Rec.	4·24	108	...
„ .	Oban	6·95	177	...	*Clare*	Inagh, Mount Callan ..	9·77	248	...
„ .	Poltalloch	5·10	130	91	„ .	Broadford, Hurdlest'n.	5·75	146	...
„ .	Inveraray Castle......	8·89	226	105	*Wexf*	Newtownbarry	5·69	145	...
„ .	Islay, Eallabus.......	10·21	259	190	„ .	Gorey, Courtown Ho...	5·36	136	154
„ .	Mull, Benmore	17·40	442	...	*Kilk.*	Kilkenny Castle	4·20	107	136
Kinr.	Loch Leven Sluice	6·04	153	168	*Wic* .	Rathnew, Clonmannon	4·62	117	...
Perth	Loch Dhu	12·85	326	148	*Carl* .	Hacketstown Rectory .	5·62	143	144
„ ..	Balquhidder, Stronvar.	10·61	269	...	*QCo.* .	Blandsfort House.....	4·77	121	143
„ ..	Crieff, Strathearn Hyd.	8·47	215	195	„	Mountmellick	4·39	111	...
„ ..	Blair Castle Gardens ..	5·64	143	161	*KCo.*	Birr Castle...........	3·34	85	108
„ .	Coupar Angus School..	4·99	127	179	*Dubl.*	Dublin, FitzWm. Sq...	3·64	93	136
Forf.	Dundee, E. Necropolis.	5·09	129	209	„ .	Balbriggan, Ardgillan .	3·63	92	126
„ .	Pearsie House........	6·30	160	...	*Me'th*	Drogheda, Mornington	...	..	...
„ .	Montrose, Sunnyside..	4·38	111	165	„ .	Kells, Headfort......	3·96	101	116
Aber.	Braemar, Bank	5·99	152	156	*W.M*	Mullingar, Belvedere .	4·18	106	123
„ .	Logie Coldstone Sch. ..	3·94	100	128	*Long*	Castle Forbes Gdns....	4·61	117	128
„ .	Aberdeen, King's Coll..	4·23	107	143	*Gal* .	Ballynahinch Castle ..	11·16	283	187
„ .	Fyvie Castle	3·95	100	...	„ .	Galway, Grammar Sch.	5·31	135	...
Mor .	Gordon Castle........	2·78	71	97	*Mayo*	Mallaranny..........	12·86	327	...
„	Grantown-on-Spey	2·63	67	88	„ .	Westport House......	10·02	255	204
Na .	Nairn, Delnies........	2·26	57	96	„ .	Delphi Lodge	18·30	465	...
Inv. .	Ben Alder Lodge	7·58	193	...	*Sligo*	Markree Obsy.	5·71	145	137
„ .	Kingussie, The Birches	3·59	91	...	*Cav'n*	Belturbet, Cloverhill..	3·17	81	102
„ .	Loch Quoich, Loan....	12·60	305	...	*Ferm*	Enniskillen, Portora ..	3·41	87	...
„ .	Glenquoich	...	..	...	*Arm.*	Armagh Obsy.	3·09	78	109
„ .	Inverness, Culduthel R.	3·28	83	...	*Down*	Warrenpoint	...	..	...
„ .	Arisaig, Faire-na-Squir	5·24	133	...	„ .	Seaforde	7·18	182	189
„ .	Fort William.........	8·73	222	107	„ .	Donaghadee, C. Stn...	4·13	105	135
„ .	Skye, Dunvegan......	6·82	173	...	„ .	Banbridge, Milltown .	3·27	83	119
„ .	Barra, Castlebay	4·44	113	...	*Antr.*	Belfast, Cavehill Rd. .	3·87	98	...
R&C	Alness, Ardross Cas. ..	5·33	135	133	„ .	Glenarm Castle.......	6·51	165	...
„ .	Ullapool.............	4·40	112	...	„ .	Ballymena, Harryville	5·23	133	129
„ .	Torridon, Bendamph..	8·40	213	91	*Lon* .	Londonderry, Creggan	4·97	126	121
„ .	Achnashellach	6·89	175	...	*Tyr* .	Donaghmore	4·52	115	...
„ .	Stornoway	5·04	128	86	„ .	Omagh, Edenfel	3·78	96	100
Suth.	Lairg	4·15	105	...	*Don* .	Malin Head	5·19	132	158
„ .	Tongue Manse........	3·04	77	66	„ .	Dunfanaghy	5·70	145	121
„ .	Melvich School.......	2·67	68	67	„ .	Killybegs, Rockmount.	8·39	213	133

Climatological Table for the British Empire, June, 1926

STATIONS	PRESSURE: Mean of Day M.S.L. (mb.)	PRESSURE: Diff. from Normal (mb.)	TEMPERATURE: Absolute Max. (° F.)	TEMPERATURE: Absolute Min. (° F.)	TEMPERATURE: Mean Values Max. (° F.)	TEMPERATURE: Mean Values Min. (° F.)	TEMPERATURE: Mean Values ½ max. and min. (° F.)	TEMPERATURE: Mean Values Diff. from Normal (° F.)	TEMPERATURE: Mean Wet Bulb. (° F.)	Relative Humidity (%)	Mean Cloud Am'nt (0–10)	PRECIPITATION: Am'nt (mm.)	PRECIPITATION: Diff. from Normal (mm.)	PRECIPITATION: Days	BRIGHT SUNSHINE: Hours per day	BRIGHT SUNSHINE: Percentage of possible.
London, Kew Obsy.	1013·6	− 3·1	75	43	66·0	50·0	58·0	− 1·2	52·2	85	6·4	86	+ 31	12	6·3	38
Gibraltar	1016·2	− 1·2	85	58	76·8	62·7	69·7	− 0·8	60·7	76	3·4	0	− 12	0	...	...
Malta	1013·9	− 1·7	89	60	76·3	65·1	70·7	− 2·0	66·0	81	4·0	2	0	2	9·8	68
St. Helena	1016·6	+ 3·7	69	54	62·3	56·3	59·3	− 1·7	58·6	93	3·7	70	− 33	17	...	...
Sierra Leone	1013·0	+ 1·0	92	70	87·0	73·6	80·3	0·0	76·2	84	7·2	547	+ 38	25	...	...
Lagos, Nigeria	1011·3	− 1·6	87	72	84·5	74·5	79·5	+ 0·2	75·7	87	8·1	332	−142	23	...	...
Kaduna, Nigeria	1014·3	+ 0·5	89	62	86·2	67·9	77·1	+ 0·6	72·1	83	2·3	219	+ 20	17	...	...
Zomba, Nyasaland	1024·9	+ 1·4	81	47	72·4	53·2	62·8	− 0·1	...	81	6·4	4	− 9	3	...	...
Salisbury, Rhodesia	1019·8	+ 0·1	81	37	70·4	43·9	57·1	+ 0·2	50·5	58	2·0	0	− 1	0	8·9	80
Cape Town	1022·0	+ 1·9	76	36	64·5	47·1	55·8	+ 0·1	49·0	91	5·0	44	− 71	5	...	...
Johannesburg	1024·5	+ 1·8	72	30	61·7	41·9	51·8	+ 1·1	43·5	61	1·6	3	− 1	2	8·9	85
Mauritius	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Bloemfontein	...	...	75	22	64·4	31·0	47·7	+ 0·1	36·2	68	3·0	1	− 11	1	...	...
Calcutta, Alipore Obsy.	999·4	− 0·3	107	75	96·6	81·7	89·1	+ 4.0	81·4	81	7·4	160	−142	5*	...	...
Bombay	1004·8	+ 0·8	94	78	91·0	81·8	86·4	+ 2·5	79·1	79	5·8	157	−348	11*	...	...
Madras	1003·6	− 0·2	110	77	103·3	83·9	93·6	+ 3·5	76·9	56	6·8	10	− 38	1*	...	...
Colombo, Ceylon	1008·8	+ 0·1	89	73	86·3	77·7	82·0	+ 0·3	78·7	83	9·2	337	+141	28	5·3	42
Hongkong	1006·5	+ 0·4	89	67	81·3	75·3	78·3	− 3·1	74·1	81	9·6	169	−240	18	3·1	23
Sandakan	...	...	91	74	89·1	75·8	82·5	+ 0·8	76·8	83	...	221	+ 36	15	...	...
Sydney	1020·2	+ 2·4	70	44	64·3	49·6	56·9	+ 2·3	51·8	84	4·6	36	− 85	13	5·8	59
Melbourne	1021·1	+ 2·6	66	34	58·0	45·3	51·7	+ 1·3	48·0	86	7·6	72	+ 19	12	3·8	40
Adelaide	1021·7	+ 2·7	70	41	61·6	47·3	54·5	+ 1·0	48·9	75	6·7	42	− 38	12	4·7	48
Perth, W. Australia	1019·7	+ 1·8	71	41	64·2	49·4	56·8	0·0	52·6	77	6·1	174	0	17	4·3	43
Coolgardie	1020·8	+ 1·7	75	34	64·4	42·7	53·5	+ 0·8	47·4	66	3·6	7	− 24	6	...	...
Brisbane	1019·9	+ 1·8	75	45	69·9	53·2	61·5	+ 1·3	55·9	71	3·8	135	+ 68	12	7·3	70
Hobart, Tasmania	1018·1	+ 3·8	61	37	55·7	45·7	50·7	+ 3·9	46·1	80	7·7	115	+ 59	16	3·0	33
Wellington, N.Z.	1020·3	+ 5·4	60	34	55·7	42·2	48·9	− 0·5	47·0	84	5·7	73	− 48	12	4·3	47
Suva, Fiji	1014·4	+ 0·8	86	62	78·9	70·0	74·5	− 0·4	71·8	86	7·5	424	+268	23	3·7	34
Apia, Samoa	1012·4	+ 0·8	89	67	85·5	73·9	79·7	+ 1·9	75·6	77	6·1	148	+ 17	8	7·4	65
Kingston, Jamaica	1013·5	− 0·3	92	72	90·1	73·6	81·9	+ 0·6	72·5	78	3·1	7	− 98	3	...	...
Grenada, W.I.	1014·3	+ 1·2	88	70	84·9	75·0	79·9	+ 1·0	75·7	79	6·7	227	+ 16	17	...	...
Toronto	1011·6	− 2·7	83	38	70·2	49·3	59·7	− 2·9	53·4	66	3·7	88	+ 18	12	9·2	60
Winnipeg	1012·3	− 0·2	84	36	68·5	49·1	58·8	− 3·4	50·2	66	5·0	90	+ 7	11	6·6	41
St. John, N.B.	1011·3	− 2·7	75	41	62·4	47·0	54·7	− 1·8	51·6	77	7·0	146	+ 63	16	7·3	47
Victoria, B.C.	1018·2	+ 1·3	85	47	66·7	51·7	59·2	+ 2·2	54·2	91	5·0	4	− 20	3	11·4	71

*For Indian stations a rain day is a day on which 0·1 in. (2·5 mm.) or more rain has fallen.

						[illegible]	[illegible]	[illegible]	[illegible]	66	5·0	90	+ 7	11	6·6	41
St. John, N.B.	1011·3	− 2·7	75	41	62·4	47·0	54·7	− 1·8	51·6	77	7·0	146	+ 63	16	7·3	47
Victoria, B.C.	1018·2	+ 1·3	85	47	66·7	51·7	59·2	+ 2·2	54·2	91	5·0	4	− 20	3	11·4	71

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